Implementing Nano-Imprint Capability

Robin Miles
(925) 422-8872
miles7@llnl.gov

Photolithography is a common technique for patterning features on planar substrates. Photosensitive polymer coated on the substrate is illuminated through a mask and upon development of the polymer, the pattern of the mask is transferred to the substrate. These techniques are used at LLNL to make MEMS sensors, microfluidic devices, and photonic components. While micron-sized features are common, sub-micron, achieving nanoscale features, typically require expensive equipment.

Nano-imprinting is a new method of "lithography" wherein sub-micron features are stamped into the polymer coating using a 3-D mask rather than illuminating through the traditional planar glass mask. The advantages of nano-imprinting are low cost and reduced capital equipment complexity for producing nanoscale features. Many commercial semiconductor companies are considering using this technique in their fabrication lines.

Competing sub-micron lithographic techniques such as e-beam lithography are expensive. Focused Ion Beam (FIB) fabrication is both expensive and practical for use over only a limited area of the material. A number of current and potential future projects can benefit from nano-imprinting methods. In particular, projects such as graded density targets where low densities (on the order of 1% of a 1.2 gm/cc material) are desired, structures for block-copolymers, nano-electrodes for dielectrophoresis, and new optical devices such as ring-resonators for sensors will require nanostructures that can be produced using this technique.

Project Goals

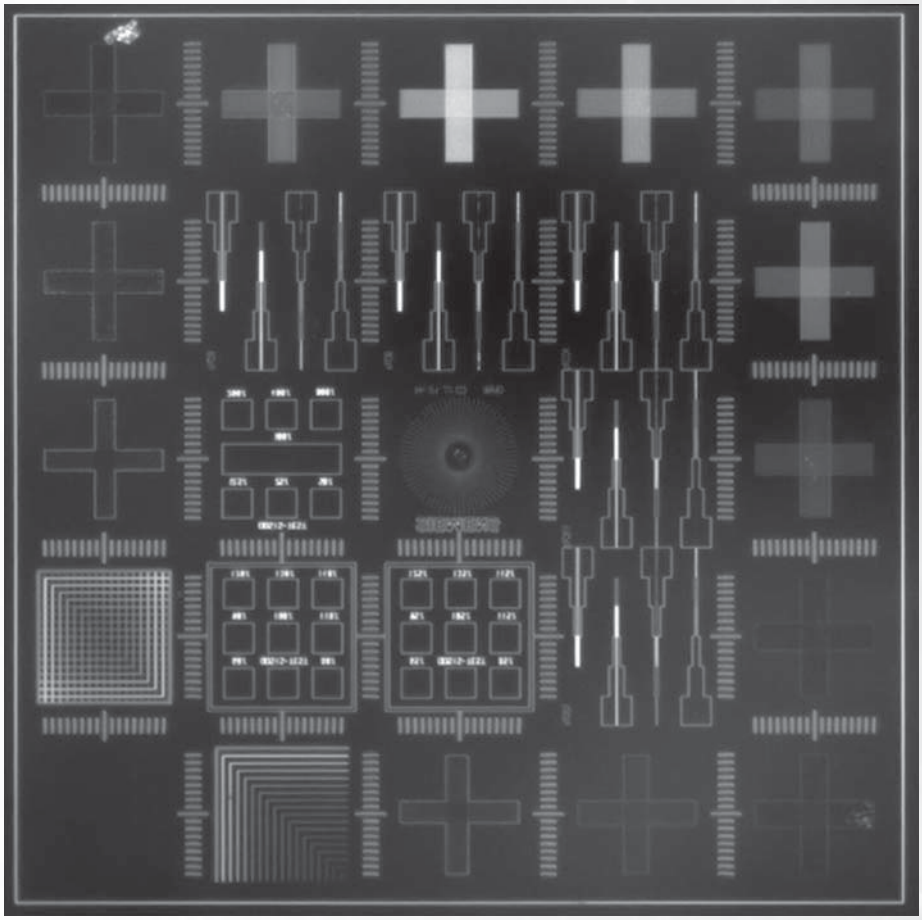
The current EV aligner in the microfabrication facility is capable of performing nano-imprint lithography. The goal of this project was to characterize this process so that this technique could be applied to future program needs.

Relevance to LLNL Mission

Several future projects may rely on the ability to produce devices with sub-micron features. Among the potential applications of this capability are the graded density reservoirs for equation-of-state targets. Other program applications include next-generation sensors for weapons surveillance, radiation detection, and bio-security where nanoscale devices and structures will lead to significantly improved performance.

FY2006 Accomplishments and Results

We received training on nano-imprinting. The equipment uses UV curable resists as opposed to the majority of nano-imprinting techniques, which use thermal processing methods. Polydimethylsiloxane (PDMS) secondary masks made from molds of a master silicon or quartz mask are used to define features across a 100-mm wafer. We purchased a quartz master mask with sub-micron features. We have used this technique to produce patterns on both glass and silicon substrates. A sample test pattern is shown on a glass substrate in the figure. Line widths of 100-500 nm are possible.



Test pattern nano-imprinted on a glass substrate.